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Variation of low-frequency sky-wave field strength with solar activity in Europe

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RESEARCH DEPARTMENT

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VARIATION OF LOW-FREQUENCY SKY-WAVE FIELD STRENGTH WITH SOLAR ACTIVITY IN EUROPE

Summary

Low-frequency sky-wave field strengths measured late at night during the solar cycle have been analysed, but no clear dependence on solar activity has been found. It is therefore recommended that the influence of solar activity on low-frequency sky-wave field strength should be disregarded for the time being.

1. Introduction

In an earlier report[1] it was shown that the strength of medium-frequency (m.f.) ionospheric waves propagated at night depends to a small extent on solar activity and that the magnitude of the effect is proportional to path length. This report describes a similar analysis of measurements made in the low-frequency (l.f.) broadcasting band.

The analysis is based on measurements made for the EBU, at various locations in Europe, of transmissions from Allouis, France, on 164 kHz. These measurements were made at regular intervals between 1953 and 1958, a period which extended over the full range of solar activity. Measurements made subsequently at Helsinki, Finland, of transmissions from Dushanbe (Stalinabad), USSR, on 254 kHz are also included in the analysis.

2. Variation of field strength with sunspot number

The data consist of median field strengths measured during one-hour periods shortly before midnight throughout the year. The method of analysis, which is identical with that used at m.f.,[1] was confined to measurements made in June and December. The time lapse between sunset and the measuring period is almost constant in these months, and field strengths measured at a fixed time are unlikely to be influenced by diurnal variations.

The field strength E (in dB relative to 1 μV/m) measured on each path was assumed to be related to the daily sunspot number R by the expression

$$E = a + bR$$

where a and b are constants. Values of the regression coefficient b were determined for each path by the normal procedure for regression analysis, the sunspot number being regarded as the independent variable. Separate analyses were made for June and December, the average number of measurements included in each analysis being about 45. Measurements which were not continued for the whole of the period (1953 to 1958) were excluded if the range of sunspot numbers encountered was less than 120, because such measurements would not be expected to yield reliable estimates of regression coefficients.

Estimated regression coefficients derived from the analysis are contained in Table 1, together with their standard errors. Although there are considerable differences between the June and December values of b on several paths, these differences are significant (at the 5% level or less) on only two paths. No further distinction is therefore made between the June and December values.

TABLE 1

Estimated Regression Coefficients

Path	Path length	Regression coefficients June	December (units of 10^{-2})	Standard errors of b June	December (units of 10^{-2})
Allouis – Monte Carlo	558	1·50	−4·33	1·05	0·63
Allouis – West Berlin	994	−2·33	−1·96	0·71	0·67
Allouis – Kolberg	1005	1·82	−6·09	2·57	3·30
Allouis – Budapest	1256	−1·71	−2·01	3·46	3·09
Allouis – Sofia	1713		1·64		1·48
Allouis – Enköping	1725	−1·67	2·83	0·98	0·70
Allouis – Helsinki	2060	−1·22	0·70	0·86	0·59
Allouis – Lulea	2350		3·91		1·84
Allouis – Vadso	2910		1·70		1·78
Allouis – Tel Aviv	3140	5·67	7·91	1·74	2·68
Dushanbe – Helsinki	3838	0·49	−2·86	1·90	1·76

3. Variation of regression coefficient with distance

At m.f. it is found that sky-wave field strength decreases with solar activity, the decrease being greater for longer distances. This trend may be seen in Fig. 3 of the earlier report, where regression coefficients derived for individual paths are plotted against distance. A linear regression analysis of this data showed that the decrease in field strength could be represented approximately by the expression $RD \times 10^{-5}$ dB, where R is the sunspot number and D is the distance in km. The use of this expression as a correction for solar activity was therefore proposed.

Fig. 1 of the present report shows that there appears to be no obvious relationship at l.f. between distance and the regression coefficients for individual paths, as there was at m.f. This was confirmed by performing a linear regression analysis of the data shown in Fig. 1, with distance as the independent variable; the resulting regression line, also shown in Fig. 1, is not significant.* There is therefore no strong evidence to support the assumption that the value of b is a linear function of distance.

The regression line shown in Fig. 1 has a positive slope, while the corresponding line derived at m.f. has a negative slope. The solar activity correction derived for m.f. is therefore unlikely to apply at l.f. This was confirmed by comparing the values of b given in Table 1 with values for the same distances derived from the m.f. regression line. Of the 19 values of b, 10 were found to differ significantly (at the 5% level or less) from the values assumed for m.f.

Fig. 1 shows that the mean value of b for all the paths is approximately zero. The hypothesis that b is zero at all distances was therefore tested. It was found that 7 of the values contained in Table 1 differed significantly from zero, at the 5% level or less. This hypothesis is therefore questionable, but its adoption is recommended for the time being for want of a better alternative.

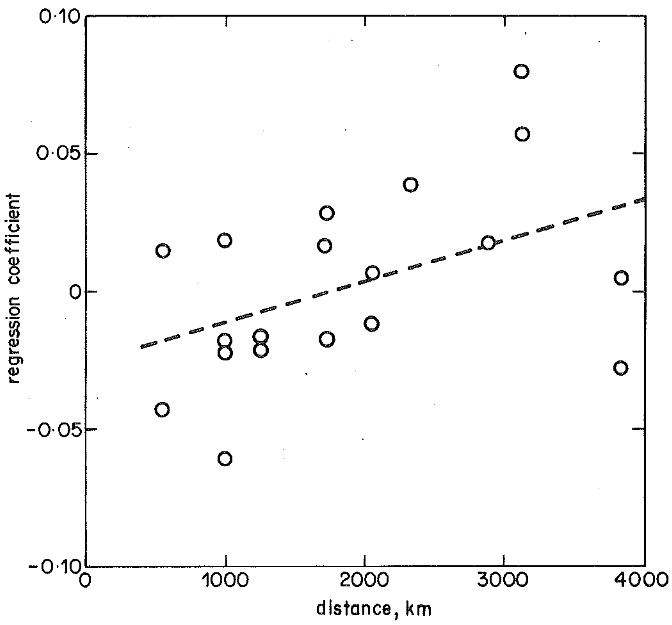

Fig. 1 - Variation of regression coefficient with distance

o Regression coefficients contained in Table 1

– – – – Estimated regression line

* The significance of regression is discussed in the Appendix to Reference 1.

4. Conclusions

At l.f. there appears to be no justification for applying the correction for solar activity which has been proposed for m.f. ionospheric propagation. There is some evidence which suggests that l.f. and m.f. sky-wave field strengths have the same trend at distances less than 2000 km and the opposite trend at greater distances. The evidence is, however, inconclusive and it is therefore recommended that no correction for solar activity be made at l.f. for the time being.

A more precise relationship between l.f. sky-wave field strength and solar activity might be obtained if more measurements were analysed. One possibility would be to apply a diurnal correction to the EBU measurements before analysis. Measurements made over the whole year instead of only two months could then be analysed.

5. Acknowledgement

Thanks are due to the Technical Director of the EBU for providing a copy of the detailed results of the measuring campaign.

6. Reference

1. Variation of medium-frequency sky-wave field strength with solar activity in Europe. BBC Research Department Report No. 1971/11.

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